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ABSTRACT

Technology now permits the transmission of caption information during the vertical interval of regular television broadcast signals. This development promises the feasibility of television for the deaf. Demonstrations of devices that televise captions are reviewed. These demonstrations have shown that three steps are necessary to put such a program into operation: 1) an inexpensive decoder-caption unit suitable for use with the home receiver must be developed; 2) a single system for accommodating the caption information associated with film program material must be developed; and 3) extensive field tests of the entire system are necessary. Characteristics of the proposed signal format and of the decoder/captioning unit are described. Transmission requirements and broadcasters' requirements for the system are also explained. (JK)

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TELEVISION FOR THE DEAF

A Paper Presented at the
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Las Vegas, Nevada

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John E.D. Ball
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TELEVISION FOR THE DEAF

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INTRODUCTION

Through the use of technology developed by the National Bureau of Standards (NBS), Boulder, Colorado, it is now technically feasible to transmit caption information during the vertical interval of regular television broadcast signals. A 'black box', connected to the home receiver, would display the captions in a fashion similar to foreign language film subtitles. It is anticipated that with the development of inexpensive 'black boxes' for home use, a welcome and needed service can be furnished by television broadcasters to those members of the public who have impaired hearing. Such a service has been called "TV for the Deaf".

"TV for the Deaf" would prove beneficial not only to the totally deaf person but also to those others who suffer from hearing impairments of one kind or another that cause the television sound signal to be frequently unintelligible. The Department of Health, Education and Welfare (DHEW) statistics[1] indicate that about 8.4% of the 18 years and over population of the United States of 133,513,000 (1970 Census) or approximately 11,000,000 persons, have hearing losses that can create difficulties particularly with speech.

BACK

As part of its ongoing responsibility, the Time and Frequency Division of NBS is continually exploring new and more efficient means of disseminating accurate time and frequency information around the nation. Since 1969, field test data has been accumulated by NBS which shows that the national television distribution systems with their wide bandwidths and high signal-to-noise ratios are nearly an ideal medium for distributing time/frequency information to a high degree of accuracy. For example, a frequency stability of about one part in 10^{11}, with

15 minute averaging, has been measured on color subcarrier signals derived from atomic standards that were transmitted over television distribution links between New York and Boulder.[2] This has lead to the development by NBS of the TvTime system which in essence would use a convenient time slot in the television vertical interval for the insertion of a highly stable sine wave signal derived from an atomic standard. This signal would be inserted at the network centers and distributed over the national television networks to all interconnected TV broadcast stations who would in turn radiate the signal to the public. As proposed by NBS, the TvTime system would provide precise time as well as precise frequency information through the transmitting of a data stream immediately following and coherent with the sine wave signal. Additionally, the data stream could be used to transmit other information and as originally suggested by NBS could be used by network control centers to transmit messages to their affiliates if they so desired. This latter application was however not novel and in fact the feasibility of such a technique was demonstrated in February 1970, using the public broadcasting facilities between Denver and Salt Lake City.[3] What was novel was the idea suggested by ABC-TV to use some of the data handling capacity of the system for transmitting captions to the hearing impaired public. In December 1971, at a National Conference on Television for the Hearing Impaired, sponsored by the University of Tennessee and held in Knoxville, the "TV for the Deaf" technique was first demonstrated by NBS with the cooperation of ABC-TV. The ABC-TV program 'The Mod Squad' was shown with captions. A similar demonstration was conducted at Gallaudet College, Washington, D.C., in February 1972. The response to both these demonstrations was most favorable and the DHEW (Bureau of Education for the Handicapped) indicated an interest in coordinating the development of a "TV for the Deaf" decoder/caption unit for the home receiver.

In January 1972, the Public Broadcasting Service (PBS), in cooperation with the major commercial television networks, participated in a National Association of Broadcasters (NAB) sponsored committee to examine the technical feasibility of providing a "TV for the Deaf" service. The final report of the NAB committee[4] while stating some misgivings about broadcasters ability to disseminate satisfactorily the time/frequency information, as proposed in the TvTime system, particularly if time-of-day must also be transmitted, concluded that the "TV for the Deaf" technique proposed by NBS was technically feasible. The committee did however point out that for "TV for the Deaf" to become a reality

the following must be accomplished:

1. An inexpensive decoder/caption unit suitable for use with the home receiver must be developed.

2. A single system for accommodating the caption information associated with film program material must be developed.

and 3. Extensive field tests of the entire system, including receivers equipped with decoders, are necessary.

The major recommendations of the NAB committee related to the design of the home receiver decoder/caption unit. These will be discussed later.

NBS PROPOSED SIGNAL FORMAT

The NBS signal format as shown in Figure 1 would be transmitted on line 21 of the vertical blanking interval. On odd fields the signal would consist of a 1MHz sine wave followed by a 26-bit data stream. On even fields the 1MHz sine wave only would be transmitted. The 1MHz sine wave would last approximately 16 microseconds and would be derived from an atomic frequency standard. Broadcasters radiating the signal after a video tape record/repro. cycle would delete the 1MHz appearing on even fields thereby indicating that the signal was no longer a valid frequency/time reference. The 26-bit data streams would of course be maintained on odd fields as it would contain the caption information. Similarly, the odd field 1MHz would also be maintained so as to simplify the home receiver decoder/caption unit design as the 1MHz would always be transmitted coherent with the data stream.

The 26-bit data stream would transmit a maximum of two ASCII* characters per odd field. Each character would use eight bits, including a parity checking bit for error detection. The remaining bits in each field would be used for other applications, such as caption identification, which could be used to send discrete messages from a network center to other broadcasters, and channel identification, which could be used to simplify home receiver tuning.

*American Standard Code for Information Interchange.

At a rate of two characters per odd field, it would be possible to transmit 3,600 characters per minute or about 600 words per minute (w.p.m.). Currently, the DHEW makes available to the deaf community, films which have been captioned at about 150 w.p.m. Radio news readers read at an average rate of about 100-125 w.p.m. Clearly the capacity of the NBS system would satisfy even the highest captioning rates.

DECODER/CAPTIONING UNIT

The design of an inexpensive decoder/caption unit that can be installed in the home receiver is of course of paramount importance in the development of a viable "TV for the Deaf" system. The NAB committee devoted much of its time and efforts attempting to define the major characteristics of such a unit and agreed on the following:

a) The minimum height of the characters should be 20 television lines and the character generator matrix should be 7x10. Also, upper case characters only should be used.

b) Two rows of captions should be displayed within the lower one third of the picture area with a maximum of 25 characters per row displayed within the safe title area.[5]

c) Left and right edging of the characters should be provided.

d) Horizontal crawl need not be considered.

The best estimates available to the NAB Committee indicated that the decoder/caption unit built into future new home receivers probably in the form of an LSI chip (see Figure 2) would raise the cost (retail) of the receiver by about $70 to $110. A totally external 'black box' decoder/caption unit (see Figure 3) that could be connected to existing home receivers would cost in the region of $100 to $200.

A possible inexpensive way devised at PBS of providing captioning using an external 'black box', is to interrupt the RF signal at the home receiver antenna terminals coincident with the detection of a character. An advantage of this approach would be that the 'black box' need not have a modulator and RF stage, as would the previous type of 'black box'.

TRANSMISSION REQUIREMENTS

Recognizing the ever increasing demands being placed on the television vertical interval for transmitting broadcaster's test and reference signals as well as many other non-broadcast related signals, NBS initially proposed that the TvTime signal be inserted on line 1 of both television fields (see Figure 4). This was a novel idea as no previous thought had been given to using this portion of vertical blanking. Unfortunately, during tests conducted by RCA in Harrison, New Jersey in May 1972, and witnessed by members of the NAB committee, disturbances to the interlacing of certain commercially available home receivers was observed when the NBS signal was inserted on line 1. As a result, the plans to use this line were abandoned. Shortly thereafter NBS adopted the PBS suggestion of trying line 21 instead. So far line 21 has proved to be a good choice and this has been substantiated through tests conducted by PBS and its member stations, where many stations have radiated the NBS signal on line 21, which is fed to them during normal program hours from PBS Washington under a Special Temporary Authority granted by the Federal Communications Commission. Concern has been voiced however in some quarters regarding the visibility of the NBS signal on line 21 in that it may prove to be annoying to the home viewer whose picture display is slightly underscanned. Fortunately most home receivers are adjusted by the set manufacturers to be overscanned and so far despite more than two months of testing by PBS and its member stations no complaints have been received from the public related to the line 21 signals. PBS has in addition, asked its member stations' personnel to complete a questionnaire on whether or not the NBS signal on line 21 is distracting when visible on their home receivers. The results of the questionnaire should be available by the end of the year.

The digital modulation technique proposed by NBS for the transmission of the caption data is a simple return-to-zero code with a 'one' bit being represented by a +50 IRE pulse and a 'zero' bit by no pulse or picture black level being transmitted. NBS predicts that even with an inferior video signal-to-random noise ratio the error rate of the caption data will not exceed about one in a thousand. However, information on the effects of other types of distortions such as impulsive noise and signal multipathing is unavailable at the present time.

BROADCASTERS REQUIREMENTS

If broadcasters are to provide a "TV for the Deaf" service, it will be necessary for industry-wide standards to be reached for handling program associated caption material on:

a. VTR material

b. Remote originations

c. Film

and d. Live studio productions

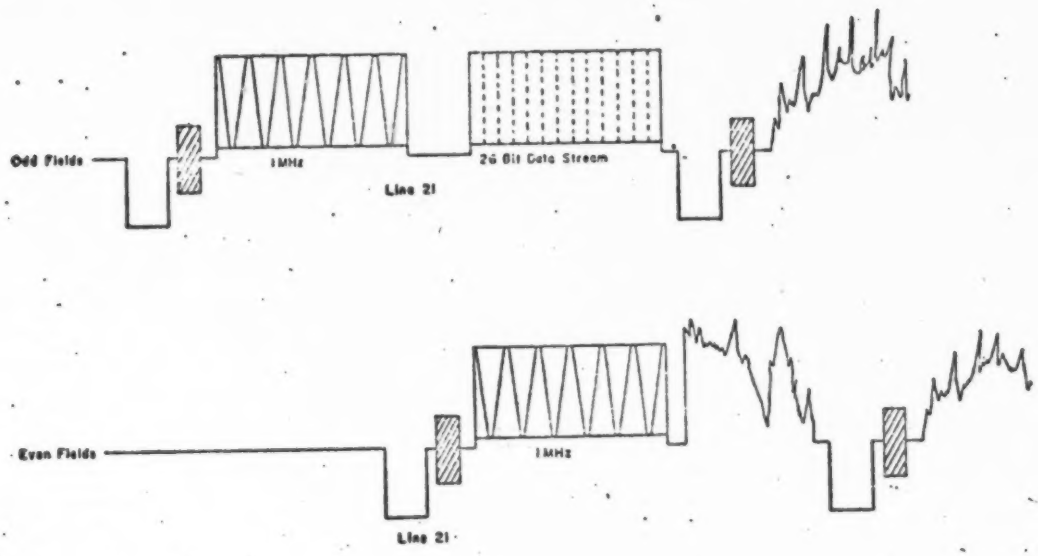
Figure 5 shows a possible network center configuration for coping with all four types of program sources. The VTR caption material could be inserted directly on line 21 and would be decoded, then re-encoded on line 21 coherent with the 1MHz cesium standard. Such a regeneration process for the captioning data would be desirable particularly if the taped caption data is second or third generation data.

For remote pick ups probably the most convenient way of transmitting the caption data would be to insert it again on line 21. Filmed program material poses a problem in that a discrete channel must be found to accommodate the caption data. The NAB committee fully recognized this difficulty and felt that inserting caption data in the film audio channel in a fashion similar to the Audicom Submerged Signaling Technique might prove to be the best approach. As shown in Figure 5 the caption data would be decoded in an audio decoder and then re-encoded for insertion on line 21. For live studio captioning which would of course be in real time the caption data could be fed directly from a keyboard in the studio to the vertical interval encoder. The broadcast network could also utilize the system for sending messages to member or affiliated stations by accessing on a time-shared basis the line 21 data channel. Finally, visual monitoring and/or automatic error detection monitoring of the caption data would also be performed at the network center.

PBS ACTIVITIES

Since the publication of the final report of the NAB committee on "TV for the Deaf", PBS has been cooperating with both DHEW and NBS on a number of different aspects of the system as presently defined. Using NBS furnished equipment PBS has successfully transmitted caption information to member stations in both Jackson, Mississippi and Los Angeles, California using line 21. Tests of a similar nature are planned in the near future to evaluate the NBS coding technique in the presence of noise and other distortions. PBS has recently developed a captioning technique applicable to video taped programs where the caption data is stored on the cue track of the video tape. This approach lends itself readily to a computer-controlled captioning process which could drastically reduce the man-hours required to caption programs. Recent collaboration between PBS and NBS has led to a significant improvement in the design of the home receiver decoder/caption unit which should result in highly readable captions being generated and displayed even with 'noisy' pictures and at little or no cost increase in the decoder/caption unit.

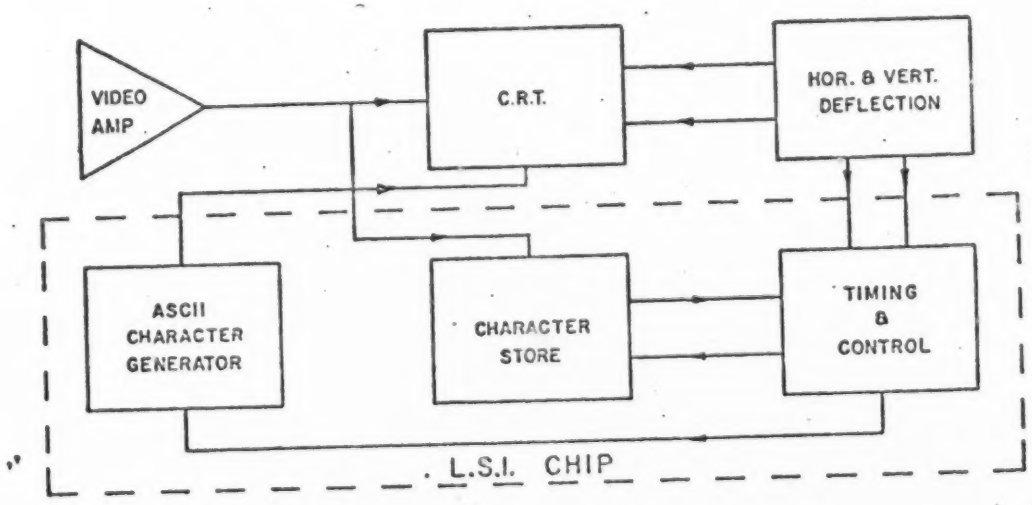
PBS has at the request of DHEW defined to NBS the major characteristics of new prototype decoder/caption units that are to be procured by NBS on behalf of DHEW for use in an extended field trial program that DHEW wishes PBS to conduct. The details of the program have been tentatively agreed upon and are now awaiting DHEW approval. In essence, the field trial would consist of PBS captioning specified programs for the deaf and they would be viewed at a number of points throughout the country by the deaf community who would comment on a number of different aspects of the captioning technique. The field trial would last from six to twelve months and its prime objective would be to refine the system and techniques used, so as to ensure that a viable "TV for the Deaf" service can be implemented by broadcasters to serve the deaf community in the most cost-effective way.



NBS PROPOSED SIGNAL FORMAT

PBS 80-319

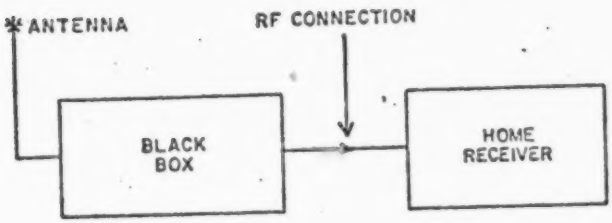
Figure 1



FUNCTIONAL BLOCK DIAGRAM OF HOME RECEIVER

MODIFIED TO PROVIDE CAPTIONING FOR THE HEARING IMPAIRED

Figure 2



FUNCTIONAL BLOCK DIAGRAM OF HOME RECEIVER

WITH EXTERNAL BLACK BOX FOR CAPTION INSERTION

Figure 3

525-LINE TELEVISION WAVEFORM SHOWING FIELD BLANKING INTERVAL

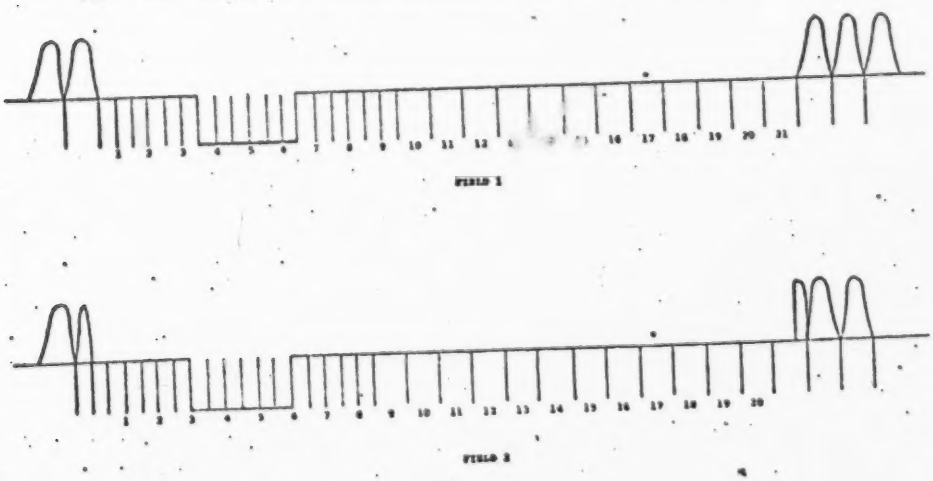


Figure 4

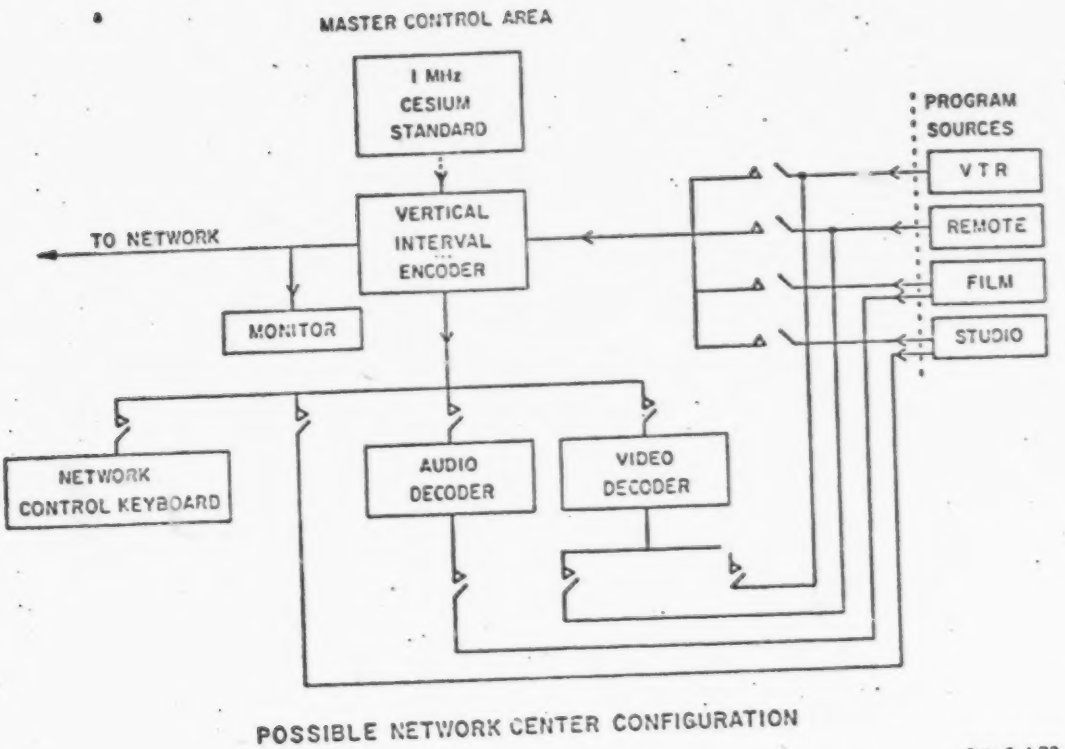

MASTER CONTROL AREA
1 MHz
CESIUM
STANDARD
PROGRAM
SOURCES
VTR
REMOTE
FILM
STUDIO
TO NETWORK
VERTICAL
INTERVAL
ENCODER
MONITOR
NETWORK
CONTROL KEYBOARD
AUDIO
DECODER
VIDEO
DECODER
POSSIBLE NETWORK CENTER CONFIGURATION
Date 5 1 72
20-519

Figure 5

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5. SMPTE Recommended Practice RP 8 - 1968, Safe Action and Safe Title Areas for Television Transmissions.